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Using the *ClassPad 300* for teaching and learning early undergraduate mathematics*

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Abstract: The paper argues that a distinction needs to be drawn between purposes of teaching and learning and other professional purposes of technology use in undergraduate mathematics. The importance of accessibility of technology for purposes of teaching and learning is emphasised and the advantages of hand-held technologies for this purpose in the early undergraduate years are outlined. Casio's *ClassPad 300*, a particular technology with great potential, is described briefly and used to illustrate three important educational roles for technology in undergraduate mathematics: computational, experiential and influential. Examples of these are given. The idea of an eActivity is described and briefly illustrated, as a new way of using technology to help early undergraduate students learn mathematics.

1 Introduction

Over recent times, there are clear trends internationally for undergraduate mathematics to respond to the fresh opportunities provided by technology. At senior undergraduate levels, it has become increasingly important for students to have access to and develop some expertise with the tools of their profession. These tools include sophisticated computer software, such as *Mathematica* and *Maple* and powerful data analysis packages such as SPSS as well as less powerful software such as Microsoft's *Excel*. Proficiency with industry-standard software of these kinds is an important outcome of undergraduate mathematics education.

Software of these kinds is not necessarily the most appropriate for teaching and learning mathematics, however, especially in the earlier undergraduate years. Of critical importance here is that technology is available to students and supports their learning. So, hand-held technologies may be superior choices over powerful alternatives. Amongst the attractions of hand-held technologies for mathematics are that they are small enough to be portable, inexpensive enough to be accessible to all students and that, by their nature, they involve students directly in mathematical work. From a teacher's point of view, when technology is hand-held, there are good prospects that teachers will be able to incorporate it into standard classrooms (rather than needing computer laboratories) and standard formal examination settings. Ideally, there should be some coherence between the conditions of teaching and learning and those of assessment, and hand-held technologies offer the best prospects for this.

Compared with other forms of computer, the screens of hand-held technologies have limitations of size, colour and resolution. Similarly, software is larger, more powerful and more comprehensive on larger computers. Such problems are technically solvable – but at a price, so that the significant accessibility advantages of hand-held technologies might be undermined. It is helpful to think of hand-held technologies as an educational compromise between mathematical capabilities and the cost to students of accessing these.

In this paper, a relatively recent example of hand-held technology, Casio's *ClassPad 300*, a photograph of which is shown in Figure 1, is described in a little detail and its implications for teaching and learning undergraduate mathematics are outlined.

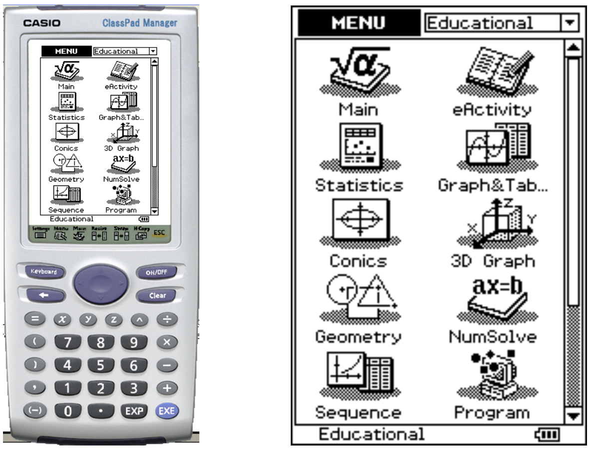

Figure 1: Photograph and opening menu of ClassPad 300

About the size of a graphics calculator, but with a larger and higher resolution screen, the *ClassPad 300* is battery-powered and driven by a stylus. It includes a suite of mathematical software, and sufficient memory to allow for this to be augmented in various ways. Critically, it offers interactive opportunities for learning mathematics that are not easily accessible otherwise. In terms of cost to students, the device is not much more expensive than a high-end graphics calculator and significantly less expensive than a PDA. The device is thus much less expensive than a computer with suitable mathematical software.

2 Three roles for technology

Educational technology for mathematics has been described as having three major roles: computational, experiential and influential. [1] While these three roles are complementary, it is helpful to describe each of them independently here and to exemplify them in the particular case of a *ClassPad 300*.

2.1 Computational role

Technology for early undergraduate student learning ought to meet the basic computational needs of students. While these will vary from course to course, the essential requirements ought to include elementary algebra, solution of elementary equations, basic differential and integral calculus, operations with sequences, matrices and elementary data analysis. Many graphics calculators, of the kinds that students use in senior secondary school, include such capabilities, provided they include computer algebra systems.

Figure 2 shows examples of some of these computational capabilities on the *ClassPad 300*. In each case, a command has been entered on the left of the screen, with the corresponding response generated by the *ClassPad 300* shown on the next line at the right. When students have access to such computational capabilities, it becomes possible to devote less attention to performing mathematical procedures by hand and to focus more attention on making sure that students understand the meanings of the mathematics involved.

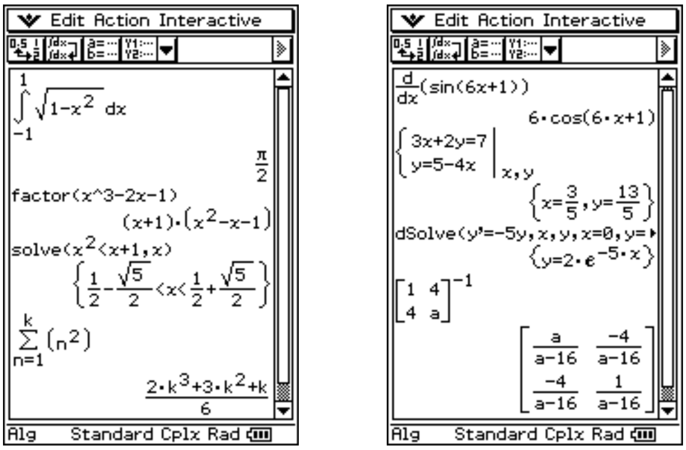

Figure 2: Examples of computations

The important balance between meanings and procedures is sometimes hard to attain, when students need to devote most of their time to mastering the procedures. In an environment in which technology is truly accessible to students, attention can focus of helping them to make sensible judgments about appropriate and thoughtful use of such capabilities, helping them to use the device efficiently and focusing on their understanding of the significance and interpretation of results produced.

2.2 Experiential role

An important reason for using technology is that it allows students to learn mathematics in a different way than is possible without the use of technology. The essence of the difference has been characterised by researchers as involving interaction between the learner and the mathematics, which comes about because of interactions between a person using the technology and the technology itself. [2], [3].

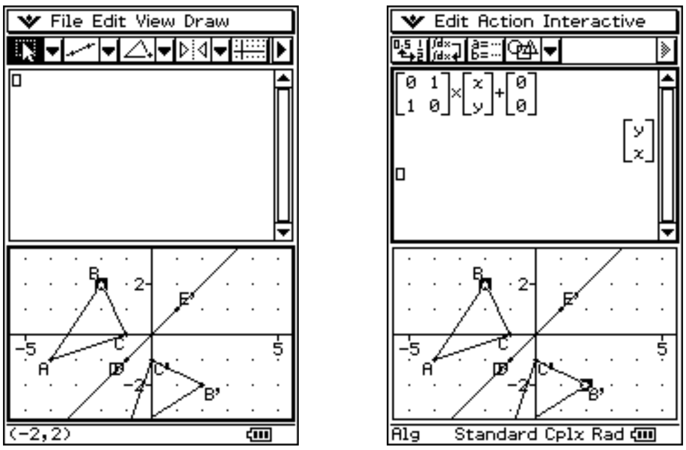

Figure 3: Interactions with an isometry

In the case of the *ClassPad 300*, there are many opportunities for this kind of interactive experience, as a result of the mathematical software built into the device and the fact that it is operated by a hand-held stylus. The screen can be divided into two separate screens, and objects moved between screens in order to see mathematical connections. Space precludes providing many examples of how the stylus can be used to manipulate mathematical objects in this way, but an example is shown in Figure 3.

In the first screen shown, some properties of an isometry (reflection) can be examined by moving vertices of the triangle ABC with the stylus. The image of the triangle in the identity line DE is automatically generated as a result, so that students can explore the nature of the reflection. The second screen shows the result of using the stylus to 'drag and drop' a point and its image (such as B and B') to the screen at the top, where a matrix representation of the reflection is automatically generated. In such an environment, students can experience mathematics in a way that is not normally accessible to them.

Many other examples of this idea are available to either creative teachers or curious students. These include connections among functions, graphs and equations, the use of simulation, and elementary data analysis. The power of this environment rests in the fact that users can perform manipulations of various kinds and explore their consequences, in a truly interactive way, examining different representations of the mathematics involved.

While many mathematical ideas and relationships can be profitably explored by free activity of this kind, teachers may prefer instead to organise and even constrain their students' work in a more directed way. On the *ClassPad 300*, small electronic activities, called 'eActivities', can be constructed to provide both a suitable environment for students to explore, as well as written instructions on how to do so and what aspects to attend to in order to maximise learning. This idea is briefly described in Section 3 of this paper.

2.3 Influential role

The availability of technology can be an important influence on key questions for the undergraduate mathematics curriculum. Assuming a finite amount of time for teaching and learning mathematics, access by all students in a class to technology such as the *ClassPad 300* would suggest that questions on the content of the curriculum, the sequencing of the mathematical ideas, the balance between by-hand and by-machine methods, and the balance between numerical and symbolic/exact methods all need to be carefully considered. When technology is less universally accessible, such questions are less critical, and thus are less likely to receive adequate attention.

3. eActivities

A novel educational feature of the *ClassPad 300* is the idea of an eActivity. [4] An eActivity consists of a small electronic activity designed by a teacher to permit students to use their *ClassPad 300* in a particular directed way for an educational purpose.

To illustrate, Figure 4 shows two screen grabs from an eActivity concerned with various aspects of polynomial functions. This particular example provides students with an environment in which to explore connections between functions and their graphs and between graphs and equations. The environment is dynamic with automatic links between elements. For example, in the screen on the right, changing the definition of the function automatically changes the graph and vice versa: changing the graph changes the definition. Changes are readily made using the stylus and the keyboard together.

There are a variety of educational uses of eActivities. [4] These include: exposition or authoritative presentation of mathematical material; the controlled practice of mathematical skills (with immediate feedback); open exploration (such as the example in Figure 4);

discovery of connections between mathematical ideas. Teachers can share eActivities; there are many examples of eActivities on the Internet for this purpose. [5]. It is possible to transfer eActivities between hand sets and between computers and hand sets, using suitable cables.

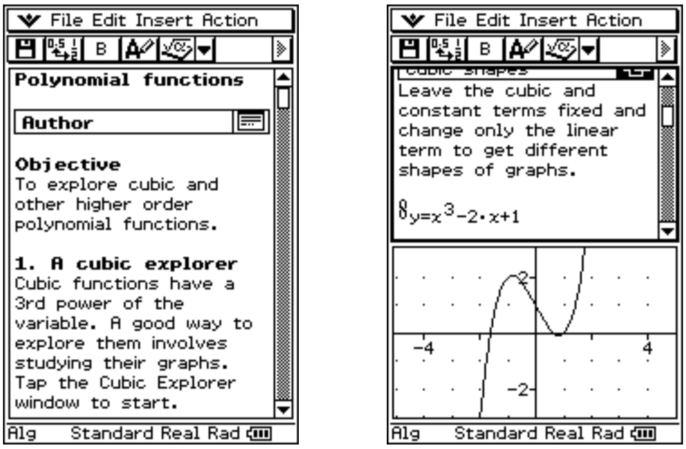

Figure 4:An eActivity concerned with polynomial functions

4 Conclusions

It is necessary to distinguish the use of technology designed for learning mathematics from that designed for use by professionals by the time of their graduation. In the early undergraduate years, the focus ought to be on making sure that all students have good access to a minimum level of technology, so that both teaching and learning mathematics can be undertaken with due regard to the fresh possibilities created. A hand-held technology such as Casio’s *ClassPad 300* provides a powerful means of doing this. Three different roles for technology have been suggested in this paper, and briefly exemplified. In addition, the concept of an eActivity has been described in the context of using technology to support the learning of mathematics.

5 References

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[5] Casio Worldwide Educational Web, http://classpad.net/.

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